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IS 3972-2-13 (2007): Methods of test for vitreous enamelware, Part 2: Test methods , Section 13 Resistance to warpage [CHD 9: Ceramicware]

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भारतीय मानक

कॉंच इनेमल माण्ड के परीक्षण की पद्धतियाँ

भाग 2 परीक्षण पद्धतियाँ

अनुभाग 13 टेढेपन से प्रतिशोधित

(पहला पुनरीक्षण)

Indian Standard

METHODS OF TEST FOR VITREOUS ENAMELWARE

PART 2 TEST METHODS

Section 13 Resistance to Warpage

(First Revision)

ICS 25.220.50; 77.080.01

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Ceramicware Sectional Committee, CHD 9

FOREWORD

This Indian Standard (Part 2/Sec 13) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Ceramicware Sectional Committee had been approved by the Chemical Division Council.

This standard was published in 1968. The Committee while reviewing IS 3972 : 1968 decided to publish this standard in two parts. Part 1 deals with production of specimens for testing in two sections, namely, Section 1 Enamelled sheet steel, and Section 2 Enamelled cast iron. Part 2 deals with various test methods applicable to vitreous enamelled sheet steel and vitreous enamelled cast iron. The Committee also decided that Part 2 shall have various sections and each section will deal with a particular test method.

This standard prescribes the method for determination of resistance of vitreous enamelware to warpage. The other sections of Part 2 are as follows:

Section 1	Resistance to citric acid at room temperature and boiling temperature
Section 2	Low and high voltage test for detection and locating defects
Section 3	Resistance to boiling water and water vapour
Section 4	Resistance to thermal shock
Section 5	Resistance to hot alkali (sodium hydroxide)
Section 6	Reflectance and specular gloss
Section 7	Resistance to boiling hydrochloric acid
Section 8	Resistance to heat
Section 9	Resistance to dilute sulphuric acid at room temperature
Section 11	Resistance to abrasion
Section 12	Resistance to torsion
Section 14	Resistance to adherence

This standard covers a procedure for determining the warpage of vitreous enamelled flatware prior to installation as well as after installation.

Measurements prior to installation are made of the deviation of the free specimen from a vertical reference plane (free position).

In the other case measurements are made of the deviation and waviness from flatness remaining in the specimen (a) after forcing the edges of the specimen into a plane (clamped position), and (b) after the specimen is actually installed in walls, ceilings, etc (installed position).

The composition of the Committee responsible for formulation of this standard is given in Annex A

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHODS OF TEST FOR VITREOUS ENAMELWARE

PART 2 TEST METHODS

Section 13 Resistance to Warpage

(First Revision)

1 SCOPE

This standard (Part 2/Sec 13) prescribes the method of test for determination of resistance of vitreous enamelware to warpage.

2 REFERENCE

The following standard contains provisions which through reference in this text, constitute provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

IS No.	*Title*
2717 : 1979	Glossary of terms relating to vitreous enamelware and ceramic-metal systems (*first revision*)

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 2717 shall apply.

4 APPARATUS

4.1 Vertical Reference Plane

The vertical reference plane shall consist of a vertical or nearly vertical surface of dimensions larger than the specimens to be measured, and plane to within 1.0 mm. A smooth plaster wall, a panel of plywood, or a sheet of plate glass at least 6 mm thick may be used. An ordinary linear scale, graduated to 1.0 mm shall be used for measurements against the vertical reference plane.

4.2 Horizontal Reference Plane

The horizontal reference plane shall consist of a piece of plate glass, 6 mm thick and flat within 0.1 mm, resting on a table top or other surface which shall be approximately flat and level.

4.3 Clamping Apparatus

The clamping apparatus shall consist of four 62 mm × 5 mm angle irons, two of which shall be at least 300 mm longer than the greatest width, and two of which shall be longer than the greatest length of any specimen to be tested. All angles shall be padded on one flange with a single thickness of cloth, attached with an adhesive, to prevent scratching of the plate glass. Each upright flange shall be equipped with two movable clamps, as shown in Fig. 1.

Any similar adjustable clamping device may be used to replace the illustrated clamps. The angle irons and clamps shall be arranged on the flat plate glass as shown in Fig. 2.

NOTE — The term warpage is considered to include any deviation from flatness of normally flat surface of a finished vitreous enamelware.

4.4 T-Beam Gauge

The T-beam gauge as shown in Fig. 3 is used for measurements in clamped position. It consists essentially of a dial indicator mounted on a carriage designed to slide along the bottom flange of a T-beam which is supported at the ends by adjustable legs. The dial indicator shall have a range of 20 mm and an accuracy of 0.1 mm. The T-beam shall be drilled at intervals so that the distance between legs may be shortened, if desired.

5 TEST METHOD

5.1 Measurement of Warpage in Free Position

Many specimens when warped into a twisted position may easily be forced into the reverse direction of twist and will retain either position, if not disturbed. Each specimen should be measured in the position of maximum distortion.

5.1.1 The specimen is tested with long dimension upright and the face side against the reference plane. Place the two lower corners of the specimen against the vertical reference plane, or if warpage prevents both from touching, place them as closely as possible to, or equally distant from, the surface. Next, allow the top of the specimen to move gently towards the surface until some part of the specimen touches and brings the specimen to rest. Support the specimen in this position,

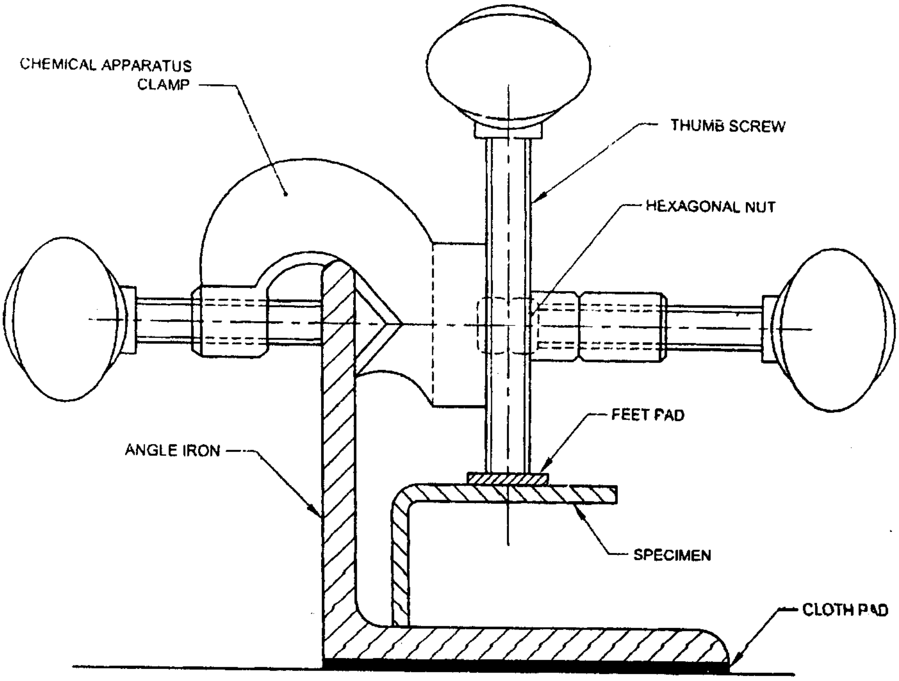


FIG. 1 CLAMP AND CROSS SECTION OF ANGLE IRON AND PORTION OF FLANGED SPECIMEN

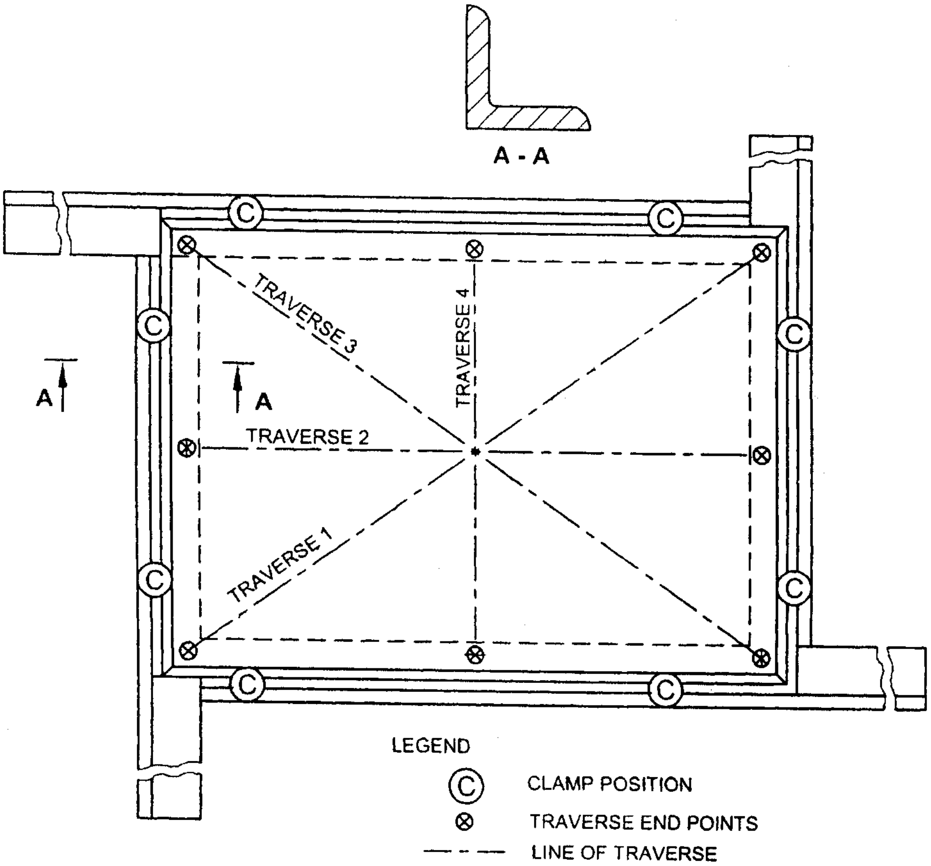
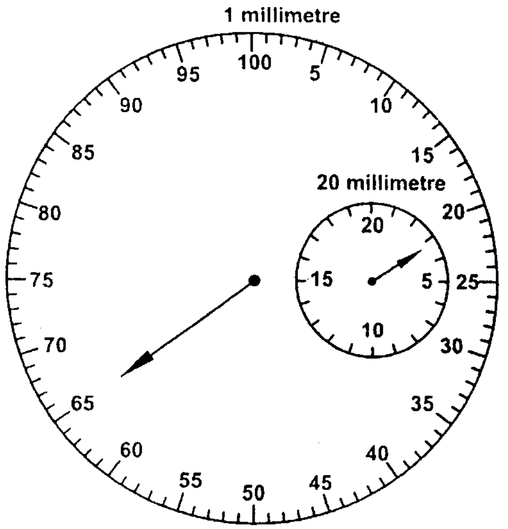


FIG. 2 DIAGRAM REPRESENTING TOP VIEW OF SPECIMEN IN CLAMPED POSITION AND SHOWING LOCATION OF CLAMPS AND OF LINES TRAVERSED BY DIAL GUAGE



NOTE — Dial readings are in hundredth of 1 mm scale in 20 mm dial gauge (each small reading = 0.01 mm).

FIG. 3 T-BEAM GAUGE

if necessary, by pressure on the back of the specimen at the spot where contact with the wall brought it to rest. With a rule measure the distance of the test surface at the two upper corners of the specimen from the vertical reference surface to the nearest 1.6 mm.

5.1.2 *Calculation*

Calculate the warpage of the specimen in terms of angle of twist per unit length as follows:

$$T = \frac{1\,000\,(D_f - D_e)}{LW} \qquad \ldots(1)$$

where

T = twist in percent per centimetre;

D_f = distance of the further corner of the two upper corners of the specimen from the vertical reference surface, in mm;

D_e = distance of the closer corner of the two upper corners of the specimen from the vertical reference surface, in mm;

L = length of specimen, in mm; and

W = width of specimen, in mm.

5.1.3 *Sample Calculation*

Assume D_f = 94 mm

D_e = 34 mm

L = 1 000 mm

W = 600 mm

From formula (1), $T = \frac{1\,000\,(94-34)}{1\,000 \times 600}$

$= 0.1$ percent/centimetre

$= 10$ percent/metre.

5.2 Measurement of Warpage in Terms of Deviations and Waviness Index in the Clamped Position

5.2.1 Fix specimen inside the frame of angle irons. Mark with a pencil the four corners of the specimen, 12.7 mm from the boundaries of the flat portion, and also four cross marks midway between the corners, 12.7 mm from the respective boundaries. Place the specimen inside the frame of angle irons resting on the glass plate, as illustrated in Fig. 1. Press down each corner by hand, tighten the thumb screws until all four corners are held snugly against the angle irons.

5.2.2 *Adjustment of T-Beam*

Place the T-beam gauge across the angle irons and specimen with the legs resting on the plate glass as shown in Fig. 4. Adjust the single leg at one end of the T-beam until the T-beam is parallel with the glass. This condition will be indicated by identical readings of the dials when its stem is resting on a steel block or similar object placed on the glass alternately at the respective ends of the T-beams.

5.2.3 *Procedure*

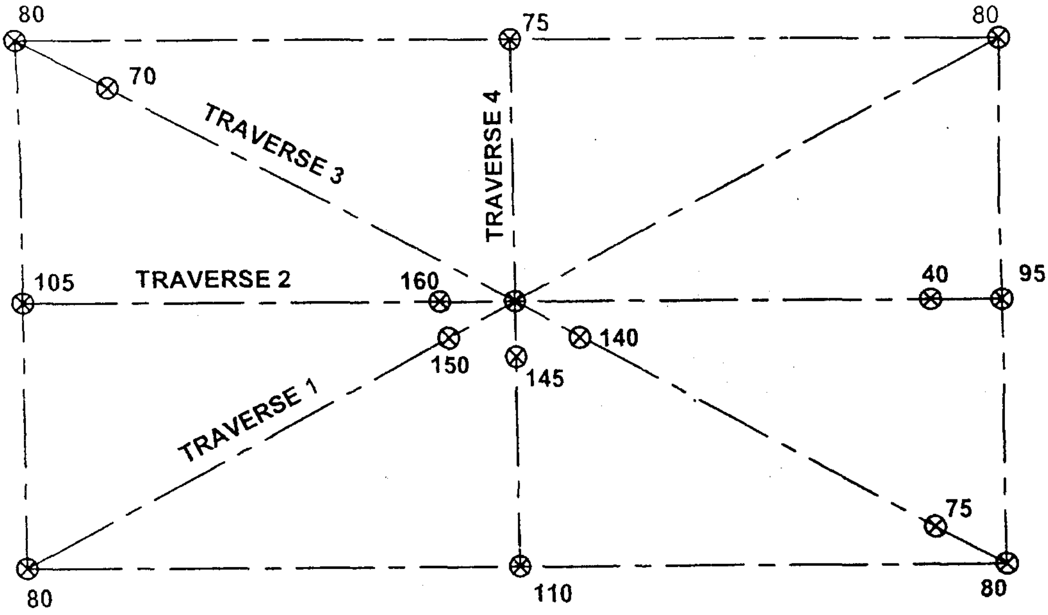
5.2.3.1 Take dial readings of the relative height of the four corners of the specimens at the spots marked by crosses. By means of shims (such as paper filing cards) placed under the extended ends of the angle irons as shown in Fig. 4, raise all corners of the specimen not already in such position to the level of the highest corner. After this adjustment, the readings of the four corners shall be within 0.1 mm.

5.2.3.2 Push the dial along the T-beam, causing its stem to traverse the specimen in four directions, namely, two diagonals between the cross marks at opposite corners, and two paths connecting the crosses at the midpoints of opposite edges as shown in Fig. 2. Traverse No. 4 (*see* Fig. 2) may be made by moving the whole T-beam while leaving the dial indicator in the centre of the beam, then avoiding the necessity of shortening the effective length of the T-beam by moving the legs inward.

5.2.3.3 All of these traverses intersect at the centre of rectangular specimen. Record on the specimen the dial readings at the eight cross marks around the outer edge of the specimen. In each traverse, note each point on the specimen at which a reversal in the direction of rotation of the dial indicator occurs, and record at each such point the corresponding dial reading. The position and relative height of every crest and trough in each traverse, will thus be recorded. The results indicate the deviations and the waviness as given in **5.2.3.4** and **5.2.3.5**.

5.2.3.4 *Deviations*

The positive and negative deviations are computed by



All dimensions in millimetres.

FIG. 4 SPECIMEN WHICH HAS BEEN MEASURED BY CROSSED CIRCLE FOR WARPAGE IN CLAMPED POSITION

subtracting the average of the four corner readings (which must agree within 0.1 mm as specified above) from maximum and minimum readings respectively, on the entire specimen. Deviations above the corners thus have a positive sign and those below the corners a negative sign. If no reading exceeds the average of the corners readings, the deviation will be zero.

5.2.3.5 *Waviness*

The results may fall into either of two categories as follows:

a) Recording of twelve readings, representing two end readings and one intermediate reading for each traverse, does not show any evidence of waviness, but indicates only that the specimen is bulged.

b) If more than twelve dial readings are made, calculate and record the differences between all adjacent pairs of readings in each traverse having more than three dial readings. Discard the two largest such differences found in each traverse, and for the four traverses collectively, separate all the remaining differences into two groups, namely, those less than 1.25 mm in magnitude, and those 1.25 mm or greater. Designate the number of the former as W_f (number of minor waves) and number of the latter as W_l (number of major waves). Calculate the index of waviness, W, as follows:

$$W = 5\,W_l + W_f$$

5.2.4 *Sample Calculation*

Assume the data as shown in Fig. 4.

Deviation:

400 – 200 = 4 mm – 2 mm = +2 mm

100 – 200 = 1 mm – 2 mm = – 1 mm

Waviness:

Traverse		Differences
1	378 – 200 = 3.78 – 2	= 1.78
	378 – 200 = 3.78 – 2	= 1.78
2	400 – 262 = 4.00 – 2.62	= 1.38
	400 – 100 = 4.00 – 1.00	= 3.00
	238 – 100 = 2.38 – 1.00	= 1.38
3	200 – 176 = 2.00 – 1.76	= 0.24
	350 – 176 = 3.50 – 1.76	= 1.74
	350 – 188 = 3.50 – 1.88	= 1.62
	200 – 188 = 2.00 – 1.88	= 0.12
4	362 – 275 = 3.62 – 2.75	= 0.87
	362 – 188 = 3.62 – 1.88	= 1.74

Remaining Differences:

From traverse 2	...... 1.38 W_l
From traverse 3	...... 0.24 W_f
From traverse 3	...... 0.12 W_f

$W_l = 1$, $W_f = 2$

$W = 5\,W_l + W_f$

$= (5 \times 1) + 2$

$W = 7$ (waviness index)

5.3 Measurement of Warpage in Terms of Twist, Deviation and Waviness in Installed Position

Determine the warpage of flat, vitreous enamelled items installed in walls, ceilings or other locations where sufficient support can be provided around the specimen for the legs of the T-beam gauge, as follows:

> Mark the centre of the specimen and make four traverses as described in **5.2.3.2**. In making each traverse, adjust the T-beam until the two end readings are equal to within 0.1 mm. On the diagonal traverses, record the dial readings at the centre of the specimen in addition to the values described in **5.2.3.3**. Identify these centre readings as reading C_1 and C_2. If the centre reading happens also to represent a crest or trough, record it separately without a subscript.

5.3.1 *Twist*

Calculate the amount of twist as follows:

$$T = \frac{2\,000}{L \times W}(E_2 - E_1 + C_1 - C_2) \qquad \ldots(2)$$

where

T = twist, percent/centimetre;
L = length of specimen, in mm;
W = width of specimen, in mm;
E_2 = average readings at corners of traverse 2, in mm;
E_1 = average readings at corners of traverse 1, in mm;
C_1 = centre reading of traverse 1, in mm; and
C_2 = centre reading of traverse 3, in mm.

5.3.2 *Deviations*

For each traverse, separately calculate from the recorded dial readings the deviations above and below the average end readings, that is the readings at the two ends of the traverse. Report the largest such deviations for the entire specimen.

5.3.3 *Waviness*

Calculate waviness as described in **5.2.3.5**.

5.3.3.1 *Sample calculations*

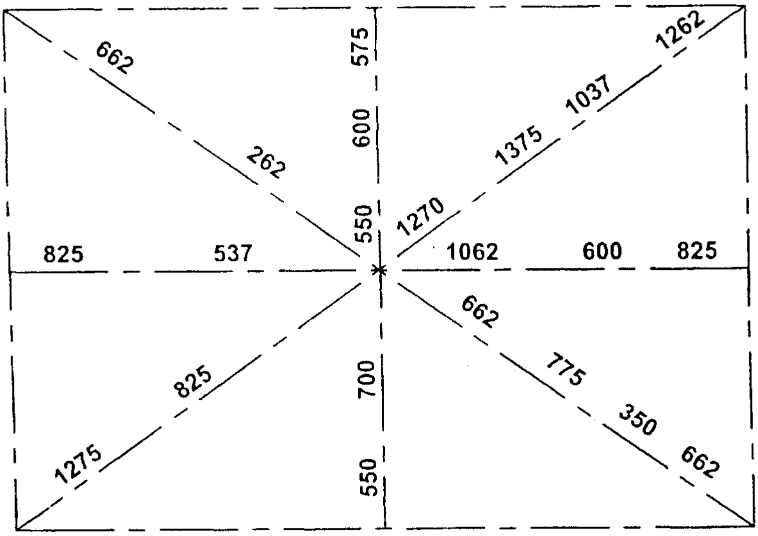
Assume data as shown in Fig. 5.

The essential difference between Fig. 5 and Fig. 4 are: (a) the respective centre readings for the two diagonal traverses are recorded, although they do not represent maxima and minima, and (b) the corner readings differ by more than 0.125 mm. These differences are due to the fact that installed specimens must be measured as found, without benefit of a flat reference plane.

L = 625 mm
W = 1 300 mm

From formula 2,

$$T = \frac{2\,000}{625 \times 1\,300}(6.62 - 12.70 + 12.00 - 7.00)$$
$$= 0.002\,6 \text{ percent/cm}$$
$$= 0.26 \text{ percent/m.}$$



All dimensions in millimetres.

FIG. 5 INSTALLED SPECIMEN WHICH HAS BEEN MEASURED FOR WARPAGE IN TERMS OF TWIST DEVIATION AND WAVINESS IN INSTALLED POSITION

Deviations:

Traverse		Differences
1	13.75 – 12.70	= + 1.05
	8.25 – 12.70	= – 4.45
2	10.62 – 8.25	= + 2.37
	5.37 – 8.25	= – 2.88
3	7.75 – 6.62	= + 1.13
	2.62 – 6.62	= – 4.00
4	7.00 – 5.62	= + 1.38
	5.50 – 6.62	= – 1.12

Maximum Deviations:

+ 2.37 mm
– 4.45 mm

Waviness:

Traverse		Differences
1	12.75 – 8.25	= 4.50
	13.75 – 8.25	= 5.50
	13.75 – 10.37	= 3.38
	12.62 – 10.37	= 2.25
2	8.25 – 5.37	= 2.88
	10.62 – 5.37	= 5.25
	10.62 – 6.00	= 4.62
	8.25 – 6.00	= 2.25
3	6.62 – 2.62	= 4.00
	7.75 – 6.62	= 2.13
	7.75 – 3.50	= 4.25
	6.62 – 3.50	= 3.12
4	6.00 – 5.50	= 0.50
	6.00 – 5.75	= 0.25
	7.00 – 5.50	= 1.50
	7.00 – 5.50	= 1.50

Remaining Differences:

Major:

From traverse 1 ...... 3.38
From traverse 1 ...... 2.25
From traverse 2 ...... 2.88
From traverse 2 ...... 2.25
From traverse 3 ...... 4.00
From traverse 3 ...... 3.12

Minor:

From traverse 4 ...... 0.50
From traverse 4 ...... 0.25

$W_1 = 6, \qquad W_f = 2$

$$W = 5\,W_1 + W_f$$
$$= (5 \times 6) + 2$$

$W = 32$ (Waviness index)

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Ceramicware Sectional Committee, CHD 9

Organization	*Representative(s)*
Central Glass & Ceramic Research Institute, Ahmedabad	Dr K. N. Maiti (***Chairman***)
All India Pottery Manufacturers Association, Kolkata	Shri S. K. Ghosh Shri S. Chatterjee (*Alternate*)
Central Glass & Ceramic Research Institute, Kolkata	Representative
Cera Sanitaryware Ltd, Kadi	Shri M. K. Bhandari Shri V. K. Jain (*Alternate*)
Chemicals & Allied Products Export Inspection Council, Kolkata	Shri S. K. Ghosh Shri K. K. Bhatia (*Alternate*)
College of Ceramic Technology, Kolkata	Representative
Controller of Quality Assurance, Kanpur	Shri S. K. Srivastava Shri Girish Trivedi (*Alternate*)
E. I. D. Parry (India) Ltd, Ranipet	Shri R. Kartikeyan Shri A. K. Mishra (*Alternate*)

Organization	*Representative(s)*
Export Inspection Council of India, New Delhi	Shri Karam Chand Shri B. Bahadur (*Alternate*)
Hindustan Lever Research Centre, Mumbai	Dr Nimish Shah Dr J. Chatterjee (*Alternate*)
Hindustan Sanitaryware and Industries Ltd, Bahadurgarh	Shri R. K. Somany Shri Sandeep Somany (*Alternate*)
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Shri S. N. Chatterjee
Scientist 'E' (CHD), BIS

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